# Cost Benefit Analysis of Bamboo Reinforcement with Steel

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## ABSTRACT

*The utilization of bamboo reinforcement as replacement of steel reinforcement is gaining immense importance today, mainly on account of the improvement in the economical aspect combined with ecological benefits. There is need to study this material as a permanent replacement of bamboo. For this dissertation we are going to take the point for carrying out the cost benefit analysis. Research is done on the fact that bamboo can be used as replaceable material but it cost benefit analysis is to be done first. This dissertation has carried out a review study regarding use of bamboo as material and the study regarding cost benefit analysis is to be carried out on a designated site in Pune region. From this paper it will clear that weather the bamboo material is to replace with other is okay as far cost is too be concern. Finally, some recommendations for future studies are proposed with the hope that the newly developed material could contribute, on a large scale, to sustainable development without harming our globe.*

***Keywords*** **:** *Bamboo, replacement material, cost benefit analysis* **.**

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## 1. INTRODUCTION

Bamboo is giant grass, not a tree. Bamboo culms are a cylindrical shell divided by solid transversal diaphragms at nodes and have some intriguing properties such as high strength in the direction parallel to the fibers, which run longitudinally along the length of the culm, and low strength in a direction perpendicular to the fibers. The density of fibers in cross-section of a bamboo shell varies with thickness as well as height. Fiber distribution is more uniform at the base than at the top or the middle. This is because bamboo is subjected to maximum bending stress due to wind at the top portion of the culm (Ghavami 2004) Bamboo is a natural Functionally Graded Material (FGM). It is a composite with hierarchical structure. The strength of bamboo is greater than most of the timber products One of the properties that would make bamboo a good substitute to steel in reinforced concrete is its strength. The strength of bamboo is greater than most timber products which are advantageous, but it is approximately half the tensile strength of steel.

Bamboo is easily accessible as it grows in almost every tropical and subtropical region, this lowers the cost of construction and increases the strength of the buildings that would otherwise be unreinforced. One major problem with bamboo is that it attracts living organism such as fungi and insects. Bamboo is more prone to insects than other trees and grasses because it has a high content of nutrients. In order to combat this problem, it becomes necessary to treat bamboo to protect it from the environment. Steel does not have this problem but it also needs to be coated in order to protect it from rusting. Bamboo is very light in weight compared to steel. Due to its low modulus of elasticity, bamboo can crack and deflect more than steel reinforcement under the same conditions. These aspects put bamboo on the list of viable construction materials. These properties, when combined, suggest that bamboo will make a fine addition to the current selection of materials, but it is necessary that people in general be made more familiar with its strengths and weaknesses. The forest area, over which bamboos occur in India, on a conservative estimate, is 9.57 million hectares, which constitutes about 12.8% of the total area under forests (Bahadur and Verma 1980). Out of the 22 genera in India, 19 are indigenous and three exotic. Bamboo is the fastest growing, renewable natural resource known to us. It is a small wonder, therefore, that this material was used for building extensively by our ancestors. It has a long and well established tradition as a building material throughout the tropical and sub-

tropical regions. It is used in many forms of construction, particularly, for housing in rural areas. But, enough attention had not been paid towards research and development in Bamboo as had been in the case with other materials of construction including timber.

Other materials : Steel and other composite set of materials is to used for comparison but the topic can be used as future scope for topic where steel is to be replaced by any other set of sustainable material.

Bamboo is one of the oldest building materials used by mankind. The bamboo culm, or stem, has been made into an extended diversity of products ranging from domestic household products to industrial applications. Examples of bamboo products are food containers, skewers, chopsticks, handicrafts, toys, furniture, flooring, pulp and paper, boats, charcoal, musical instruments and weapons. In Asia, bamboo is quite common for bridges, scaffolding and housing, but it is usually a temporary exterior structural material. In many overly populated regions of the tropics, certain bamboos supply the one suitable material that is sufficiently cheap and plentiful to meet the extensive need for economical housing With the advancement of science and technology and the tight supply of timber, new methods are needed for the processing of bamboo to make it more durable and more usable in terms of building materials.

Studies have been done on the basic properties and processing bamboo into various kinds of composite products. The proximate chemical compositions of bamboo are similar to those of hardwoods, except for the higher alkaline extract, ash and silica contents. The carbohydrate content of bamboo plays an important role in its durability and service life. Durability of bamboo against mold, fungal and borers attack is strongly associated with the chemical composition. This behaviour is unlike wood, where most of the properties will start to change when it reaches the fiber saturation point. Moisture content, height location in the culm, presence of nodes and orientation of the outer bark affect the mechanical and physical properties. The presence of nodes, moisture content and culm location had a significant effect on strength. The presence of nodes reduced the compression, tension strength and MOR, but did not significantly affect MOE. The top location of the culm exhibited higher compression strength, tension strength, MOR and MOE. In bending, radial or tangential loading had a significant effect on MOR and MOE

The durability of bamboo can be greatly enhanced by appropriate specification and design and by careful use of safe and environmentally friendly preservatives such as boron. A bamboo building need not look "low-cost" or even necessarily look like bamboo. The density of the fibers in the cross section of a bamboo shell varies along its thickness. The thickness decreases from the base to the top of the bamboo shell. Fiber distribution is more uniform at the base than at the top or the middle part, since bamboo is subjected to maximum bending stress at the base, owing to the wind and its own weight. A mathematical formula, relating thickness (t), to the position of the inter-node (n), is established for all species. The equation for DG is as follows…..

$$T = -0.0003n3 + 0.025n2 - 0.809n + 16.791.$$

## 2. SURVEY CONDUCTED

A set of 20 questions were prepared so as to get review from the expert in this field regarding the approach of replacing the steel with bamboo. Some of the few question are regarding the durability strength parameters and use of organic material as a part of concrete. There were mixed review which were also reviewed on the Likert Balance Scale. Mean and variance was calculated which help us to come for the following points which were of more importance:

a) Improving the Physical and chemical properties of bamboo so as to increase the strength capacity and hence durability.

b) Alternative source of admixtures which might help in increase the bonding property of the bamboo with water and aggregates.c) Specialized set of test which will be based on using bamboo as a reinforcing material.

d) The cost effectiveness or the Cost Benefit Ratio of replacing bamboo.

The last was of outmost important Question which actually acted as driving force for the project and can be considered as problem statement for this dissertation work.

### 3. PROBLEM STATEMENT

1) Bamboo can be used as replaceable material but it cost benefit analysis is to be done first. .this should need to clear that weather the bamboo material is to replace with other is okay as far cost is too be concern.

2) Primarily the study of bamboo as a sustainable material is to be done and various sustainability related test such as tensile strength, flexural strength, curing process, organic content test etc.

3) Secondly comparison of steel and bamboo as a reinforced material in terms design stability from existing case study chosen and one from the study area where the project is to be implemented.

4) Lastly the cost comparison of steel and bamboo and by which is carried out by conducting cost benefit analysis.

## 4. METHODOLOGY

The dissertation report in framed on a series of specialized research. A set of 20 questions were also prepared to get a glance of the construction industry its view over bamboo as reinforce material.

**Table -1:** Likert Balance Scale

| 1-Worse | 2-Bad | 3-Average | 4-Good | 5-Excellent | | |
|---|---|---|---|---|---|---|
| No. | Question | Likert Balance Scale | | | | |
| | | 1 | 2 | 3 | 4 | 5 |
| A) | **Material** | | | | | |
| Q1) | How much u consider the idea of replacing steel as a reinforced Material in Concrete Structure? | | | | | |
| Q2) | According to you how much reliable you consider the bamboo to be used as replaceable? | | | | | |
| Q3) | What is possibility of Availability of Special admixtures which can used with bamboo | | | | | |
| Q4) | What is level up to which you consider the use of organic material in constructions. | | | | | |
| Q5) | Up to what level you think bamboo like material will be able to replace more steel in future. | | | | | |
| | | | | | | |
| B) | **Strength & Durability** | | | | | |
| Q1) | Do you consider bamboo to be as durable material which can sustain as with good strength | | | | | |
| Q2) | How much design parameters should be changed in the structure of bamboo? | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Split, Node, Fibrous nature etc.? | | | | | |
| Q3) | Will the bamboo be able to withstand the nature's severity i.e flood , earthquake etc. up to what level.? | | | | | |
| Q4) | How much is the Requirement of specialized processing unit for bamboo treatment? | | | | | |
| Q5) | Whether bamboo can be reused after used in construction as recycled material? | | | | | |
| | | | | | | |
| C) | **Cost and Management Issue.** | | | | | |
| Q1) | How easily is the bamboo available in local market? | | | | | |
| Q2) | How much is the need of importing best quality of bamboo from foreign land. | | | | | |
| Q3) | Is there need of provision of précised laboratory facility for defining the strength quality of bamboo. | | | | | |
| Q4) | Do you consider the Initial investment in replacing the bamboo as reinforced material is more? | | | | | |
| Q5) | Though the Initial cost ( Research and Development) is more will it be able to take bamboo as reinforced material if it is cheaply available as compare to steel | | | | | |
| Q6) | Do you think people will be able to live in the house considering the fact that they have bamboo but not steel means question of reliability. | | | | | |
| Q7) | How much percentage of cost should be reduced if steel is to replaced by bamboo | | | | | |
| | | | | | | |
| | **General Question** | | | | | |
| Q1) | Replacement of steel by bamboo should be certified by any international scrutiny? (for eg ISO Certification) | | | | | |
| Q2) | Will bamboo get a designation of a more greener material and sustainable as if in a green building is considered | | | | | |
| Q3) | Based on the experimental way of bamboo as | | | | | |

| | |
|---|---|
| | replacement what floors of building will be the limit |

**4.1 Design Consideration**

Design of steel as reinforced structure is to be taken for a G+5 of M/s Malhotra Developers building located in Balewadi Pune Region. Similar building is to taken for the design by replacing Bamboo as a reinforced material. At the end cost benefit analysis is to be done to decide whether bamboo can be replaced thoroughly as per cost is concerned so that it reduced the load on the steel.

## 5. DESIGN PRINCIPLES

Bamboo reinforced concrete design is similar to steel reinforcing design. When design handbooks are available for steel reinforced concrete, the equations and design procedures can be used to design bamboo reinforced concrete if the above mechanical properties are substituted for the reinforcement. Due to the low modulus of elasticity of bamboo, flexural members will nearly always develop some cracking under normal service loads. If cracking cannot be tolerated, steel reinforced designs or designs based on unreinforced sections are required. Experience has shown that split bamboo performs better than whole culms when used as reinforcing. Better bond develops between bamboo and concrete when the reinforcement is-split in addition to providing more compact reinforcement layers. Large-diameter culms split into 3/4inch- wide splints are recommended.

Bamboo reinforcement can be assumed to have the following mechanical properties.

**TABLE -2:** Some general specific properties of Bamboo are as given below

| Sr. No. | Properties of Bamboo | Value |
|---|---|---|
| 1 | Specific Gravity | 0.570-0.650 |
| 2 | Average Weight | 0.625 kg/m |
| 3 | Modulus of rupture | 610-1600kg/cm2 |
| 4 | Modulus of Elasticity | 1.5-2.0x105kg/cm2 |
| 5 | Ultimate Com. Stress | 794-864 kg/cm2 |
| 6 | Safe working stress in compression | 105 kg/cm2 |
| 7 | Safe working stress in tension | 160-350kg/cm2 |
| 8 | Safe working stress in shear | 115-180kg/cm2 |
| 9 | Bond Stress | 5.6 kg/cm2 |

Bamboo as reinforcement in concrete can increases the load carrying capacity of the structure. Bamboo possesses low modulus of elasticity compared to steel. So, it cannot prevent cracking of reinforced concrete under ultimate load. Rahman et.al (2011) were evaluated the performance evaluation of bamboo as reinforcement in concrete beam. They have conducted tensile test for bamboo species and flexural strength test for bamboo reinforced concrete beam. In this research three types of different beam were used first beam was designed and casted as plain reinforced concrete, second one was designed and casted as singly reinforced beam and last one was designed and casted as doubly reinforced beam having same dimensions. In plain reinforced concrete beam, they used one bamboo stick. In singly reinforced bamboo reinforced beams they used two bamboo sticks placed at the bottom with 25mm clear cover. Similarly, in doubly bamboo reinforced beams they used two bamboo sticks placed at the top and bottom with 25mm clear cover. Compressive Strength Test and Splitting Tensile Strength Test were conducted for cylindrical concrete specimen. Flexural strength test was conducted for beam. Tensile Strength Test was conducted for Bamboo Stick in UTM machine

### 5.1 Design of First Floor

This Design can be repeated for all the floors and analysis replacement will be carried out.

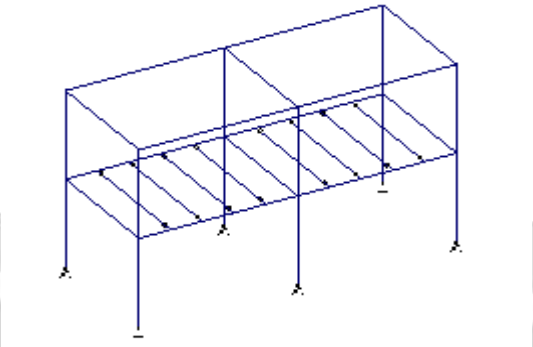

**Fig -1**: First Floor Structure

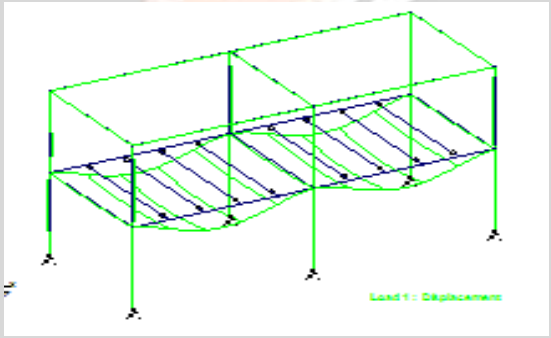

**Fig -2**: Design of first floor

## 6. Cost Benefit Analysis

Cost-benefit analysis (CBA) is the implicit or explicit assessment of the benefits and costs (i.e., pros and cons, advantages and disadvantages) associated with a particular choice. In this paper we are going to discuss the comparison of bamboo and steel as reinforced for construction and in our case Bamboo becomes our choice. Very less amount of research is done regarding this topic.CBA can be carried out manually and using Excel template sheet. Some specified and customized software and tools are available in construction market which actually performed cost benefit analysis. In this paper we have just giving the model in which the format the cost benefit analysis is to be carried out.

The step wise cost benefit analysis to be done from a referenced study and categorized into Slab Column etc.

**TABLE -3:** FORMAT FOR COST BENEFIT ANALYSIS

| Material | Rate | RCC Design | Amount |
|---|---|---|---|
| Steel | | | |
| Concrete | | | |

| | | | |
|---|---|---|---|
| Formwork | | | |
| Total | | | |

This is the simplest format in which cost benefit analysis can be done in categories. After completing the design parameters one can go for the analysis which also can be considered as future scope of this project.

## 7. CONCLUSIONS

Bamboo can be replaced by considering all the parameters of strength and durability as compared to steel and considering the market prices difference between the bamboo and steel bamboo can be given chance of replacing. Though there is chance of increase in the cost regarding the research to be done on improving the durability of bamboo (Growing and Process), but it can be considered as one time initial investment because as compare to the steel bamboo can always be considered as renewable material.

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